(12) UK Patent Application (19) GB (11) 2 250 658 (13) A

(43) Date of A publication 10.06.1992

(21) Application No 9026679.2

(22) Date of filing 07.12.1990

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(51) INT CL⁵
H04R 1/24

(52) UK CL (Edition K)
H4J JAB J30F J30L J31H

(56) Documents cited
GB 2081052 A GB 2056815 A GB 1554349 A
GB 0537931 A GB 0469286 A GB 0445935 A

(58) Field of search
UK CL (Edition K) H4J JAB JBA
INT CL⁵ H04R 1/24 9/06 11/02

(54) **Loudspeaker**

(57) A twin concentric loudspeaker comprises an inner treble dome 10 and an outer dome-shaped midrange transducer 15, the surfaces of the midrange dome 15 and the treble dome 10 being arranged to conform approximately to a spherical surface so that reflection of high frequency signals from the treble dome 10 by the midrange dome 15 are substantially minimised, the midrange dome being driven at its outer edge by a separate magnetic circuit.

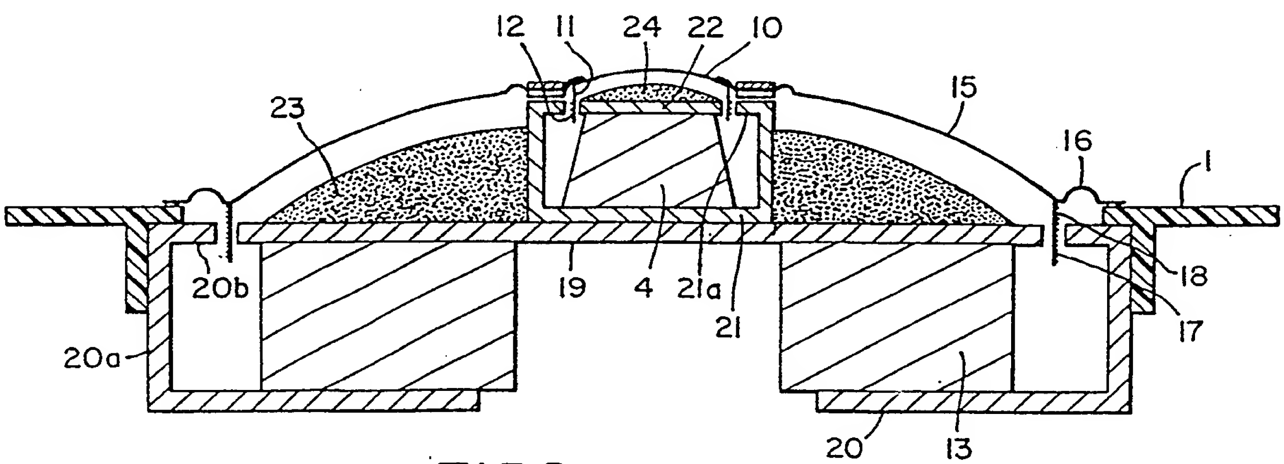

FIG.3

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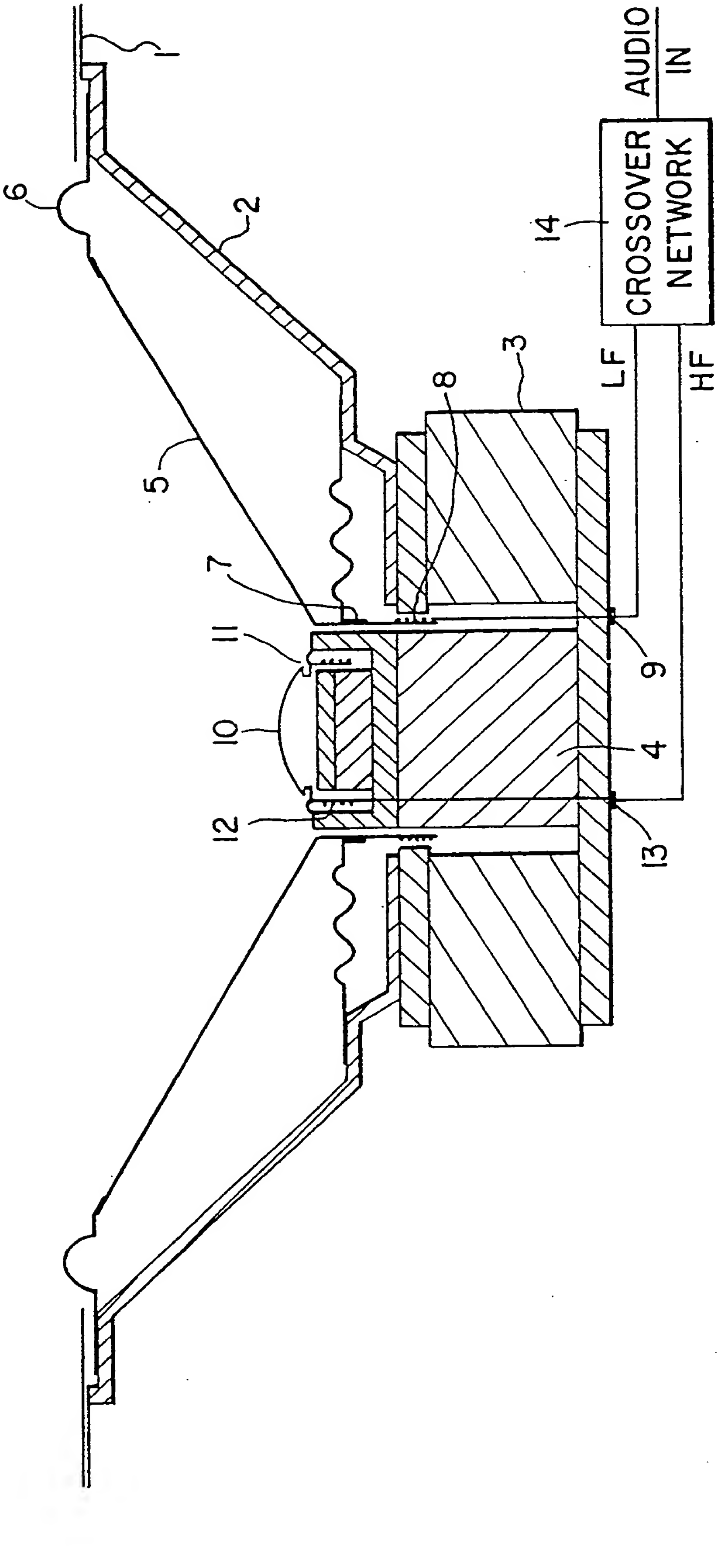

FIG. 1.

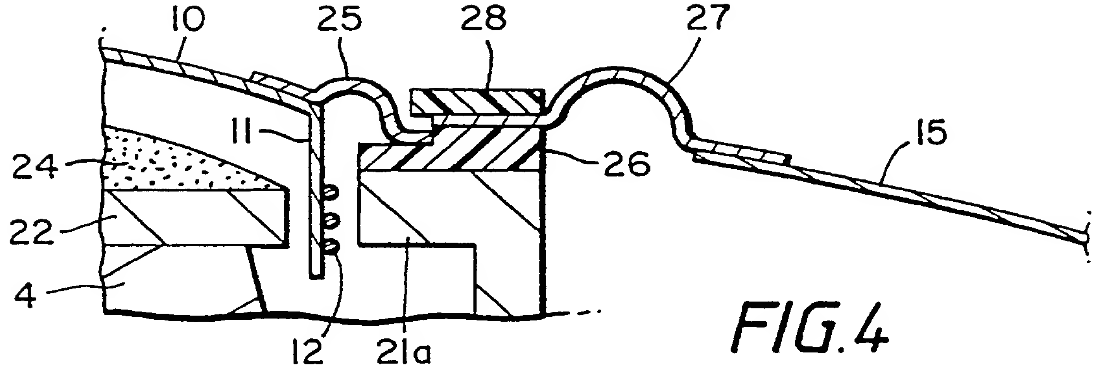

FIG. 4

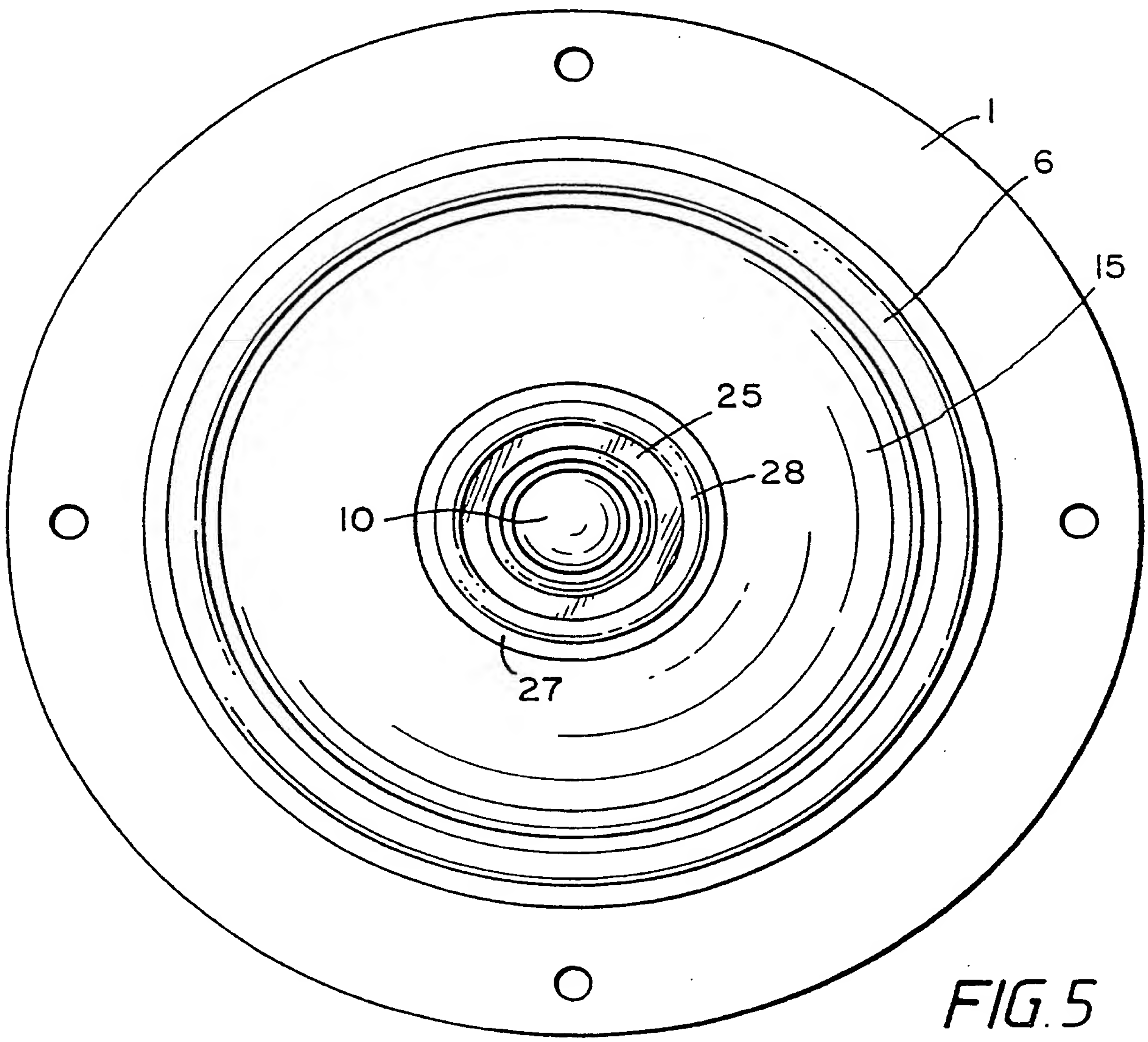

FIG. 5

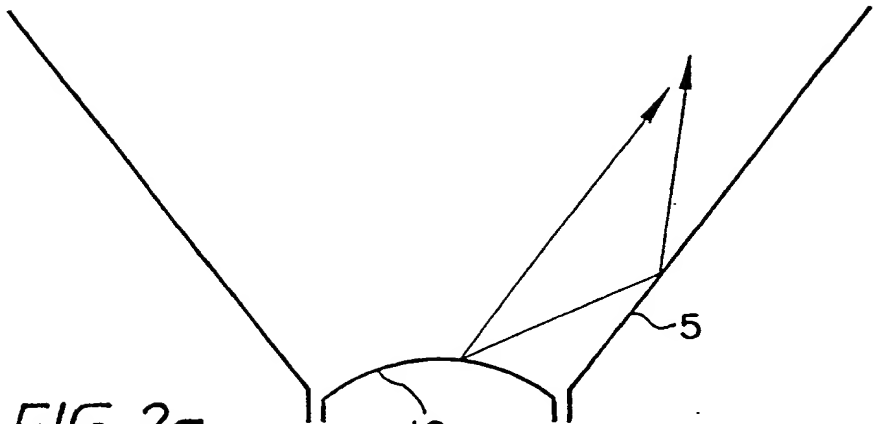
5
10

FIG. 2a

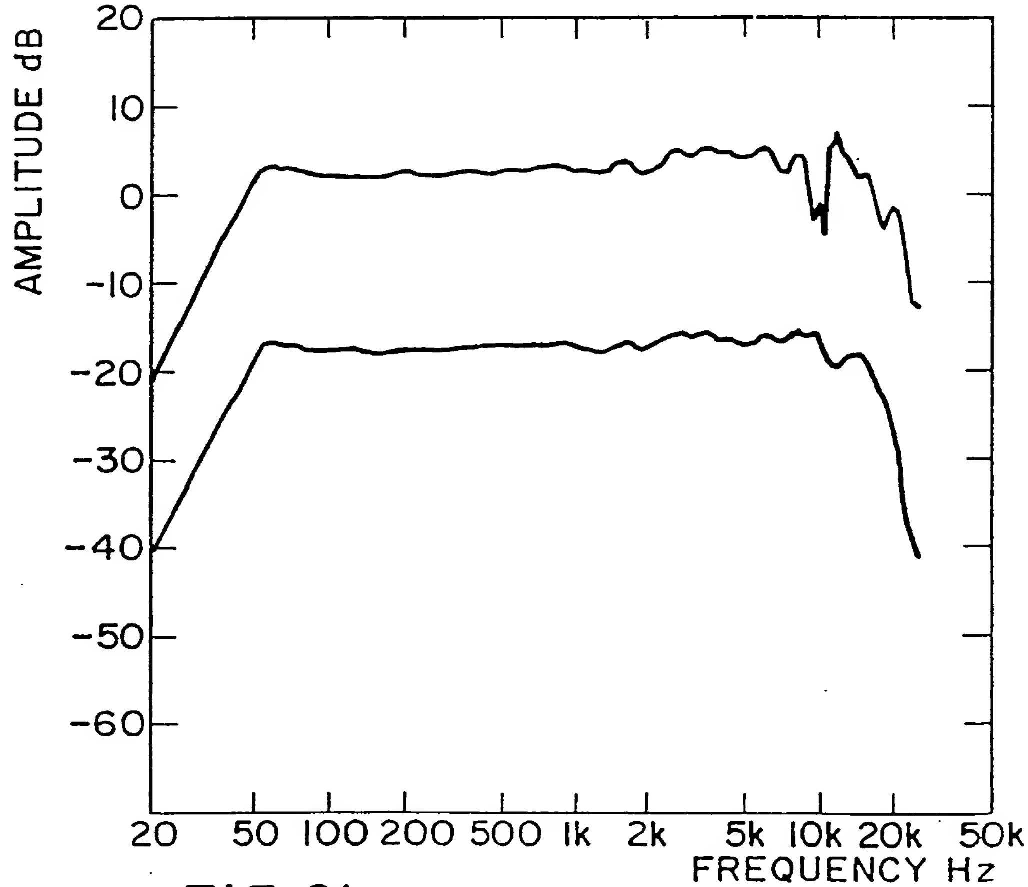
AMPLITUDE dB
20
10
0
-10
-20
-30
-40
-50
-60
20 50 100 200 500 1k 2k 5k 10k 20k 50k
FREQUENCY Hz

FIG. 2b

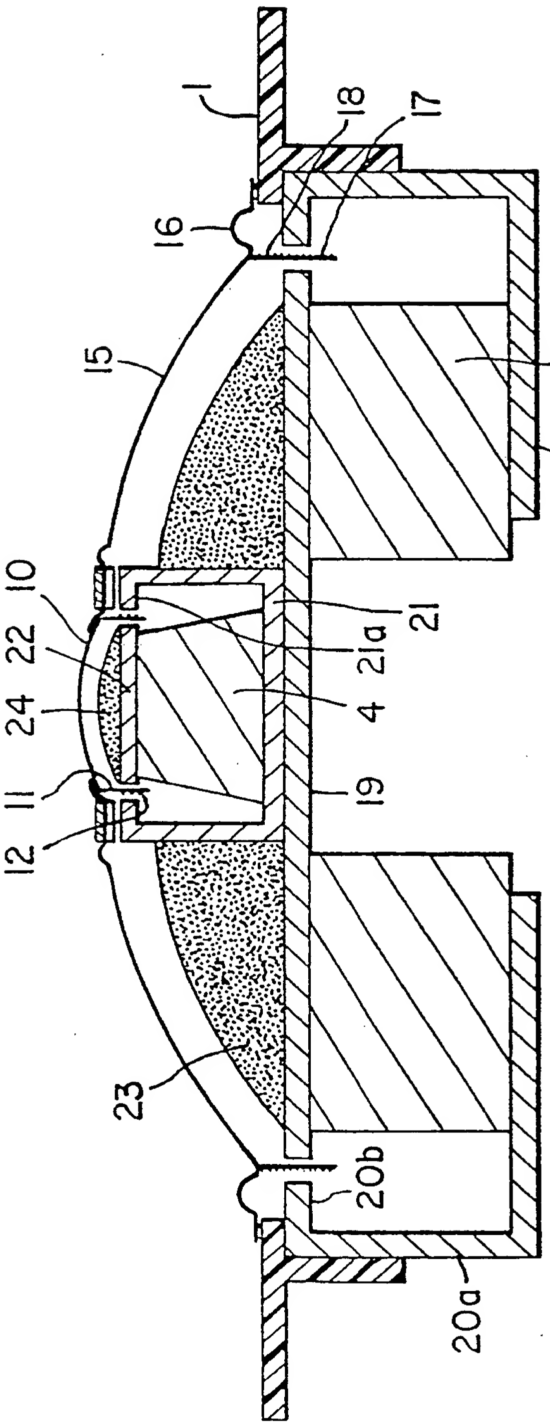

FIG.3

LOUDSPEAKER

This invention relates to a multi-range concentric loudspeaker.

Known multi-range (e.g. twin) frequency loudspeakers comprise an outer cone of suitably stiff material connected at the outer cone edge to a loudspeaker housing via a flexible joint. The cone is truncated at its inner edge to provide a ring which is connected to a rigid tube (the "former tube") carrying an electrical winding (the "voice coil"). The tube and electrical winding are arranged to lie within a ring shaped permanent magnet, solid with the loudspeaker housing, so that by energising the winding with an alternating current an alternating field is produced which reciprocates the cone relative to the loudspeaker housing to generate a forwardly projected sound field. The cone acts in some respects as an acoustic horn, providing efficient forward direction of the generated sound.

In a twin range concentric loudspeaker, there is located within the former tube a second high frequency sound generator. This may take the form of a second cone, but is more commonly a rigid dome connected

round a second rigid tube carrying a second winding. The outer cone is generally responsive to low or mid range audio frequencies, whereas the inner dome is responsive to high range audio frequencies. Associated with the loudspeaker (either within the loudspeaker or within the amplifier to which the loudspeaker is connected) there is usually provided a crossover network which receives an audio signal and splits the signal into a low or mid-range frequency component, which energises the winding of the outer cone, and a high frequency component, which energises the winding of the inner dome. The components are usually magnetically driven.

A problem can however arise at certain high frequencies, because the pressure wave generated by the high frequency dome will, more or less, obey the laws of optics and be reflected by the surface of the outer cone. At some frequencies, the effect of reflection will be additive, thus reinforcing the amplitude of the sound projected by the loudspeaker at those frequencies; at other frequencies, the effect will be subtractive, thus attenuating the amplitude of the audio signal at those frequencies. The overall transfer function of the loudspeaker is thus non-uniform across the high frequency range.

GB2153628 proposes to overcome "diffraction and tunnel effects" (believed to be due to the same reflection phenomena) by employing as the outer transducer a flat or backwardly directed transducer. This can, in one embodiment, be dome shaped. The construction described in that patent drives the outer transducer at its inner periphery, however, as is the case in conventional concentric loudspeakers employing an outer cone shaped transducer. Because the driving magnet must be accomodated behind the outer dome, a long former tube must be employed which we have found leads to mechanical loss or absorption, and to phase delay. It is also necessary to provide a flexible suspension ring to support the former tube and this too causes mechanical losses. The size of the magnet which can be employed is constrained, and thus so is the power achievable. Finally, because of the close proximity of the magnetic circuits for the two transducers there is inevitably some cross talk between the two magnetic circuits which reduces the performance of the transducers.

According to the invention there is therefore provided a multi-range loudspeaker comprising separately driven co-axial inner and outer transducers in which the outer tansducer is driven at its outer edge. This

separation of the drive circuits eliminates cross talk between the two magnetic circuits, allow a shorter former tube and permits use of a large magnetic stator to drive the outer dome.

It also enables damping material to be positioned behind the outer transducer, thus reducing unwanted back reflections, and obviates the need for a suspension ring.

Finally, it enables the curvature of the outer dome to be made a matter of design choice since the dome need not clear a magnetic stator positioned behind it. It is thus possible to provide conformally curved inner and outer domes, preferably both conforming to a spherical profile; this further reduces interference effects.

Other aspects and embodiments of the invention are as described and claimed herein, with advantages which will be apparent from the following.

The invention will now be illustrated, by way of example only, with reference to the drawings in which;

Figure 1 illustrates a known loudspeaker;

Figures 2a and 2b illustrate schematically the effects of high frequency audio reflection interference in this loudspeaker;

Figure 3 illustrates schematically a cross section through a loudspeaker according to an embodiment of the invention;

Figure 4 illustrates in greater detail a cross section through part of the structure of a loudspeaker according to Figure 3; and

Figure 5 illustrates a front elevation of the loudspeaker of Figures 3 and 4.

Referring to Figure 1, in the prior art a loudspeaker housing 1 has rigidly fixed thereto a loudspeaker frame 2 of generally conical form comprising a suitable steel or iron material. At the inward end of the loudspeaker frame 2 is affixed a permanent magnet stator ring 3. Solid with the stator ring 3 is an inner permanent magnetic stator 4. A low frequency cone 5 comprises a light material of suitable stiffness such as kevlar, PVC, or some suitable fibrous cardboard paper material. The cone 5 is coupled to the loudspeaker frame 2 by a flexible

coupling ring 6 which allows the cone to move forward and backwards relative to the frame.

At the inner end of the frame 2 is a former tube 7 carrying an electrical winding 8 the ends of which are coupled to a low frequency input port 9. Lying concentrically within the cone 5 is a treble dome 10 comprising a stiff material such as polyamide or polyester resin, connected at its rearward edge to a tube 11 carrying on its inner surface an electrical winding 12 connected at each end to a high frequency audio input port 13.

The high frequency audio input port 13 and the low frequency audio input port 9 are fed respectively from the high frequency and low frequency outputs of a crossover network 14, which receives an audio input signal and divides it into respective high and low frequency components above and below a crossover frequency. Thus, when an audio signal is supplied to the loudspeaker, the low frequency component causes the outer cone 5 to reciprocate relative to the stator 3 in response to the low frequency signal components in the audio signal, and the high frequency dome 10 to reciprocate relative to the stator 4 in response to high frequency components of the audio signal.

Referring to Figure 2a, considering relatively high frequencies, the low frequency cone 5 may be considered to present a reflecting surface to audio pressure wave fronts generated by motion of the high frequency dome 10. A patern of reflected wave fronts are therefore set up, which interfere with the patern of wave fronts generated by the high frequency dome 10. Where the dome 10 is mounted forwardly of the rear of the cone 5, backwardly propagating wave fronts from the dome 10 can be reflected forward by the cone 5 leading to complete cancellation at some frequencies and reinforcement at others. The frequencies at which interference is noticeable, and at which the interference is additive and subtractive, are determined by the dimensions of the loudspeaker components; the effects on a well-known loudspeaker are evident around 10kHz in Figure 2b.

Referring to Figures 3 to 5, in a loudspeaker generally according to one embodiment of the invention, the high frequency dome 10 is mounted, as before, on a tube 11 carrying a winding 12 drivable to reciprocate relative to an inner magnetic stator 4 which is solid with a loudspeaker mounting ring 1 for mounting to the loudspeaker cabinet.

However, in place of the outer low frequency cone 5 of the prior art, there is provided a convex domed low frequency audio transducer 15 of a relatively stiff material of suitable weight and stiffness to be drivable by the low frequency signal from the cross-over network 14. Suitable materials are aluminium, polyamide or polyester resin or glass or carbon-fibre mat in a suitable matrix. At its outermost edge, the low frequency transducer 15 is coupled to the loudspeaker housing 1 via a flexible coupling 16 as in the prior art. Adjacent the flexible coupling 16 is provided a surrounding tube 17 carrying an electric winding 18 feedable with a low frequency electrical signal so as to reciprocate relative to a ring shaped magnetic stator 13 solid with, and disposed backwardly from, the loudspeaker housing 1. The stator 13 is made of a suitable ceramic material (e.g. a Ferrite).

The ring-shaped stator 13 is mounted to a top plate 19 of, for example, mild steel and a bottom plate 20 typically of the same material. The bottom plate 20 is conveniently employed to mount the magnet assembly to the housing 1. The top plate 19 is disc shaped, and the bottom plate 20 has an up-standing tubular wall 20a with an inwardly turned lip 20b facing the

edge of the top plate 19. The top and bottom plates thus provide the pole pieces of the ring-shaped stator 13, and their opposed edges define a gap within which the tube 17 and electrical winding 18 are arranged to reciprocate.

It will be observed that the outer transducer 15 is driven at its outermost edge, rather than its innermost edge as in the prior art.

It will further be observed that the ring-shaped stator 13 may be as large as desired without interfering physically with the dome 15 since it is disposed backwardsly thereof. Also, the length of the tube 17 need only be sufficient to carry the winding 18 over the maximum distance of travel of the transducer 15 (which is determined by the lowest frequency to which it is responsive), so that losses in the tube are minimized.

The high frequency stator magnet 4 is disposed within a bottom plate 21 taking the form of a cup or blind tube, with an inwardly turned lip region 21a facing a top plate 22, the two plates acting as pole pieces of the upper magnet 4 and defining a gap between which

the tube 11 and winding 12 are received. As before, the plates 21, 22 may conveniently be of mild steel.

The high frequency magnetic stator 4 is arranged to taper towards its upper end, so as not to interfere with the gap between the edges of the plates 21, 22 whilst occupying as much as possible of the volume within the tubular lower plate 21 to maximise the magnetic field. A magnetic material such as a cast Alnico/Alcomax alloy, generating a high field for a relatively small material volume, is preferably employed for the magnet 4.

The low frequency stator 13 is shaped to axially surround the high frequency magnetic circuit, so as to reduce magnetic interference or crosstalk between the two.

Referring to Figure 4, it will be seen that the outer edge of the tweeter dome 10 is connected (e.g. by an adhesive) to a flexible coupling ring, or "surround", 25 similar to the ring 16. The other edge of the ring 25 is fastened (e.g. by adhesive) to a moulded plastics ring 26 fastened to the upper surface of the plate 21a. Also mounted to the plastics ring 26 is a flexible coupling or "surround" 27 connected at its

other end to the outer transducer 15. A plastics trim ring 28 may be secured over the ring 26 to conceal the edges of the surrounds 25, 27.

The connecting leads to the windings 12, 18 may be led for connection to the cross-over network 14 over the outer transducer 15, or backwardly through the plates 19, 20, 21 as desired. It will be noted that in the magnetic circuit illustrated the outer edge of the high frequency gap is of the same magnetic polarity as the inner edge of the low frequency gap, so that in order that the two coils are driven in the same direction the windings must be oppositely connected to the terminals of the cross-over network.

Seated upon the top plate 19 of the lower frequency magnet 13, and surrounding the tubular bottom plate 21 of the higher frequency magnet 4, is a ring 23 of sound absorbent material (for example felt or wool) arranged to underlie the outer dome 15. Preferably, the sound absorbent ring 23 is arranged to approximate the profile of the dome 15. This prevents sound propogating backwardly from the dome 15 and reflecting from the magnetic assembly behind, which would otherwise interfere dramatically with the sound

projected forward, in a manner considerably more noticeable than with a forward facing cone as in the prior art.

Similarly, a dome 24 of absorbent material (for example felt) is provided underlying the high frequency dome 10, seated upon the top plate 22 of the high frequency magnet 4.

It is found that the wavefronts generated from the treble dome 10 undergo significantly less interference in the forward direction from the loudspeaker in this construction. This is thought to be due to three factors:

1. the low frequency transducer 15 extends rearwardly, rather than forwardly, of the high frequency dome 10 so that interference caused by reflection off the low frequency transducer 15 is directed off the forward axis of the loudspeaker,

2. the outer periphery of the dome 10 and the inner periphery of the low frequency transducer 15 are substantially aligned, and

3. the surfaces of the low frequency transducer 15

and the high frequency dome 10 are at least approximately conformal and present a generally spherical surface, so that reflection by the low frequency transducer 15 of wave fronts propagated from the treble dome 10 is minimised.

Whilst each of these factors separately contributes to the performance of the loudspeaker, the preferred embodiment of the invention includes all three such improvements.

Throughout the description and claims, it will be understood that references to "bass" or "low frequencies" refer in relative terms to a lower frequency range supplied from a crossover network. The invention is not limited to any particular frequency ranges since the applicable principles are the same for any frequency (although, naturally, dimensions of the components employed will differ). Preferably, however, the high frequency transducer 10 operates as a convention "tweeter" and the low frequency transducer 15 operates at a mid-frequency range; the loudspeaker will also be provided with a separate coplanar mounted bass speaker (not shown) fed from a third port of the crossover network 14.

CLAIMS:

1. A multi-range loudspeaker comprising separately driven coaxial inner and outer transducers characterised in that the outer transducer is driven at its outer edge.

2. A loudspeaker according to claim 1 in which the inner transducer comprises a dome driven at its outer edge.

3. A loudspeaker according to claim 1 or claim 2 in which the outer transducer comprises a dome, surrounding the inner transducer, secured at its inner edge.

4. A loudspeaker comprising inner and outer transducers driven from inner and outer magnetic circuits, the inner magnetic circuit being disposed upon and projecting forwardly of a first side of a base plate and the outer magnetic circuit comprising a ring shaped magnet disposed upon and projecting backwardly from a second side of the plate, coaxially with and surrounding the inner magnetic circuit.

5. A loudspeaker comprising an inner audio transducer

and an outer audio transducer coaxially arranged, one of said transducers being responsive to audio signals lying in a relatively high frequency range and the other to audio signals lying in a relatively low frequency range, characterised in that the inner and outer transducers exhibit a convex curvature and the curvature of the two transducers is approximately conformal.

6. A loudspeaker according to claim 5 in which the inner and outer transducer curvatures approximate a sphere sufficiently closely to substantially minimise reflection of a high frequency audio signal propagated by the high frequency responsive transducer by the low frequency responsive transducer.

7. A multi-range loudspeaker comprising inner and outer convex transducers, characterised in that the transducers exhibit conformally curved outer surfaces.

8. A loudspeaker according to any preceding claim further comprising a portion of sound absorbant material positioned behind at least one of said transducers.

9. A loudspeaker according to claim 8 in which a said portion is positioned behind the outer transducer.

10. A loudspeaker according to claim 8 or claim 9 in which the or each portion conforms in profile to the curvature of the or each transducer behind which it lies.

11. A loudspeaker substantially as hereinbefore described with reference to the accompanying Figure 3.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number 90/26679

Relevant Technical fields	**Search Examiner**
(i) UK Cl (Edition K) H4J (JAB)	S J CARTWRIGHT
(ii) Int Cl (Edition 5) H04R 1/24, 9/06, 11/02	
Databases (see over)	**Date of Search**
(i) UK Patent Office	19 APRIL 1991
(ii)	

Documents considered relevant following a search in respect of claims

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB 1554349 (SRI) whole document	5

SF2(p)

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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